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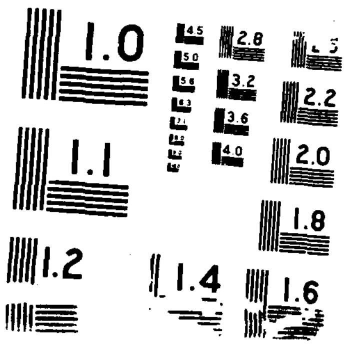
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ANNUAL REPORT FOR 1987

AFOSR GRANT 86-0076

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ABSTRACT

To date ~~we have~~ demonstrated that ~~our~~ experimental animal, the sea slug Pleurobranchaea, is capable of one-trial food-aversion learning, and that the muscarinic antagonist scopolamine in low doses causes an enhancement of learning. Pharmacologic binding studies using a new, ^{125}I-form of quinuclidinyl benzilate, in addition to studies using the ^{3}H-form of this ligand, have uncovered not only the classical types of muscarinic receptors that are typical of vertebrate cortex, but also a new form that is not found in other invertebrates that we have tested. Usually muscarinic receptors are found in low densities in invertebrate neural membranes, but the density of the new form in ~~our~~ animal's neural membranes is similar to the density of the classic receptors in mammalian cortex. Neurophysiological studies of individual neurons in small groups of identifiable neurons have shown that their activity is variable, as is the behavior that they take part in generating, and that the variability fits the definition of low-dimensional chaos. Our findings show that such variability is an important feature of the emergence of adaptive responses arising from parallel, distributed neural networks in biological systems. To test the information carrying capacity of chaotic activity, we used computer simulation of simple connectionist networks. The results show and agree with our biological experiments that the same set of connections, synaptic weights, and thresholds, can generate many different responses; i.e., the network is multifunctional. They show also that chaos can be used as an informational signal in networks, but, that learning of such signals always represents a distortion in the output by comparison to the input. In several pending publications, we have discussed the implication of such findings with regard to the generation of adaptive behavior.

REPORT FOR 1987

During the past year, January 10, 1986 to January 9, 1987, we have progressed on all levels of our proposed research project.

I. Molecular/behavioral studies on Associative Learning:

we have found that our experimental animal contains cholinergic muscarinic receptor sites resembling those found in mammalian cerebral cortex, and a second receptor site that has not been found yet in other animals

which may be an evolutionary precursor to the classical type. We have also shown that muscarinic receptors are involved in memory formation and learning in our animal, with some memory/learning being enhanced and other being reduced.

II. Cellular studies:

a) Neuroanatomy: Using immunofluorescence, we have been aggressively seeking to identify the the neural loci and individual neurons that release acetyl choline and the target neurons that have cholinergic muscarinic receptors. All of this work involves generating many new techniques that are not available in other experimental systems. The work is only about 8 months old, and, for realistic progress to occur, we need to conduct more experiments, as we are presently doing.

b) Neurophysiology: Considerable progress has been made in the analysis of the dynamics of parallel processing and self-organization of patterned activity relating to adaptive behavior. Present findings indicate that such self-organizing activity involves the mathematical definition of chaos.

III. Computer Simulation Studies:

In order to understand how neural integration takes places, and how variability/chaos takes part in such integration, it is necessary to have complete control and knowledge of all variables governing the activity of all neurons in the network. Biological preparations cannot meet such information constraints. Therefore, we have undertaken computer studies (in collaboration with Prof. Donald Perkel of the University of California at Irvine) to simulate specific aspects of our biological system. These studies involve simulation neurons that have many realistic properties that are found in biological neurons; all of these properties are accessible for analysis and control in the simulations. In addition, we have conducted simulation studies on connectionist types of networks in order to determine the ability of chaos to serve as a readable and reproducible signal in network processing.

IV. Publications:

1. Mpitsos, G. J. (1988) Chaos in brain function and the problem of nonstationarity: A commentary. In: Dynamics of Sensory and Cognitive Processing by the Brain. Basar, E., and Bullock, T. H. (eds.), Springer-Verlag, New York. In Press.
2. Mpitsos, G. J., Burton, R. M., Creech, H. C., and Soinila, S. O. (1988) Interrelated studies of chaos in neurophysiological and connectionist networks. Submitted to Brain Research Bulletin.
3. Mpitsos, G. J., Creech, H. C., Cohan, C. S., and Mendelson, M. (1988). Variability and chaos: Neurointegrative principles in self-organization of motor patterns. In: Dynamic Patterns in Complex Systems, Kelso, J. A. S., Mandell, A., and Shlesinger, M. F. (eds.), World Scientific Press, Singapore. In Press.

4. Mpitsos, G. J., and Murray, T. F., Creech, H. C., and Barker, D. L. (1988) Muscarinic cholinergic action in one-trial food-aversion conditioning: Scopolamine enhances experimental-control differences in the mollusc Pleurobranchaea. Submitted to Pharmacology, Biochemistry & Behavior.
5. Murray, T. F., and Mpitsos, G. J. (1988) Characterization of high affinity binding of [125I]3-quinuclidinyl 4-iodobenzilate to muscarinic cholinergic receptors ink nervous tissue of the mollusc Pleurobranchaea: Evidence of heterogeneity of antagonist binding sites. Submitted to Pharmacology, Biochemistry & Behavior.
6. Mpitsos, G. J., Creech, H. C., Cohan, C. S., and Mendelson, M. (1988). Variability and chaos: Possible neurointegrative principles in generation of motor patterns in the sea slug Pleurobranchaea. Soc. Neurosci. 13, 428.7.

V. Meetings and Lectures:

Because our work is so new, it is especially necessary for us to present it to national and international audiences. For this reason, since our previous Progress Report, we have presented papers on chaos theory and its application to biological systems (including our own) in 12 invited lectures/seminars, including one international conference, and three national and regional neurophysiological meetings. Although we expected (and found) resistance to our ideas, it has been encouraging that many people have been quite receptive. One result from such lectures is that several people have sought collaborative research with us so as to apply our ideas to their experimental systems.

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